GPM DPR Ground Validation using Korean Radar Network

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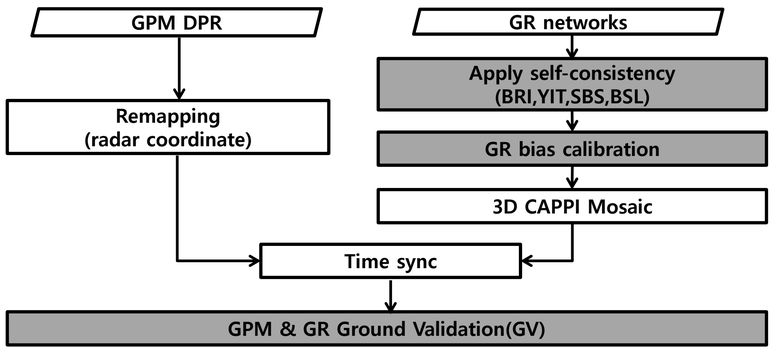
1. Background

- Global Precipitation Measurement(GPM) Dual-frequency Precipitation Radar(DPR) can observe reflectivity and estimated rainfall intensity in high latitudes. Ground based dual polarization radars can achieve stable bias correction using self-consistency constraint.
  - ✓ Systematic verification and characteristic analysis of vertical reflectivity profiles between GPM DPR and dual polarization radars.
- Extension of GPM DPR observation over high latitude
  - ✓ Possible GPM DPR snow estimation
  - ✓ Verification of GPM DPR snowfall and characteristic analysis of reflectivity for snowfall cases.

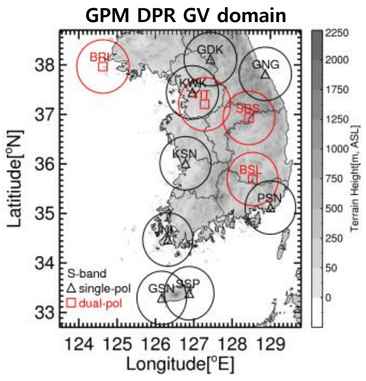
2. Methodology and data

(1) The flow chart of GV between GPM DPR and GR networks



- GPM DPR and GR network are matched at the closest time (0~5 min difference)
- Spatial resolution is 5×5×0.25 km^3 and analysis areas are observable range of radar network (150~250km)

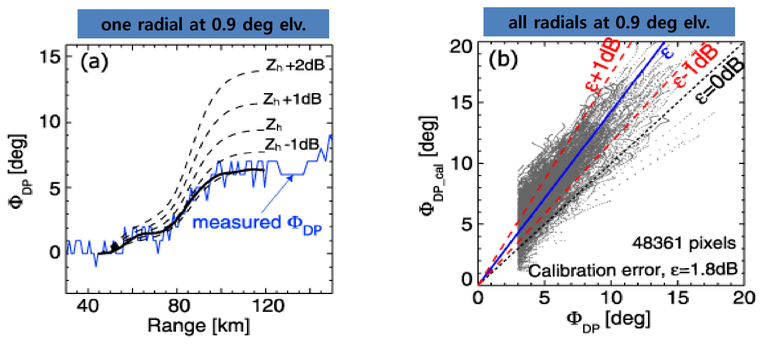
(2) Analysis domain and data



- GPM DPR(Ku & Ka band)
  - ✓ Data version : Level 2 version 03B (V03B)
  - ✓ Attenuation corrected reflectivities are used for ground validation of GR networks
  - ✓ Data period : 2014. 07 ~ 2015. 05
  - **(Rain : 7 cases, Snow : 4 cases)**
- Ground Radar(GR) networks (S band)
  - ✓ Single polarization radars : 8 Sites
    Gwangducksan(GDK), Gangreung(GNG), Kwanaksan(KWK), sungsan(KSN), Jindo(JNI),
    Guducksan(PSN), Gosan(GSN), Sungsan(SSP)
  - ✓ Dual polarization radars : 4 Sites
    Biseulsan(BSL), Sobacksan(SBS), Baekryeongdo(BRI), (Yongin Testbed(YIT))
  - ✓ After applying reflectivity bias correction, 3D CAPPI mosaic reflectivities within 60km or max observable radius are used for ground validation of GPM DPR

(3) Z_H calibration using self consistency of dual-polarization parameters and inter-comparison

The concept of calibration using self consistency

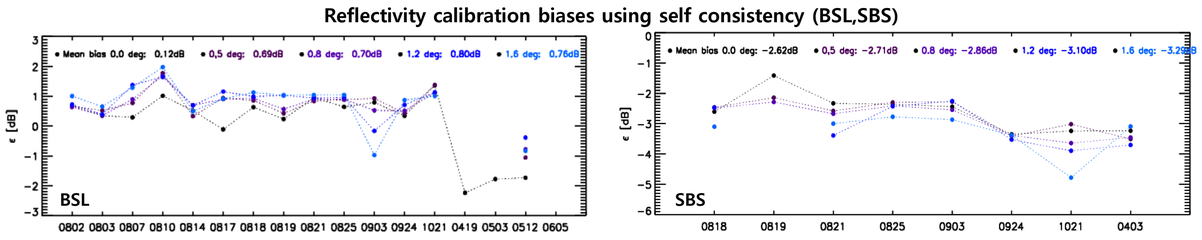


$$\varepsilon[dB] = 10b\log(\tan\theta)$$

$$Z_h = aK_{DP}^b$$

$$\tan\theta = \frac{\sum \Phi_{DP\_cal}\Phi_{DP}}{\sum \Phi_{DP}^2}$$

Reflectivity calibration biases using self consistency (BSL,SBS)



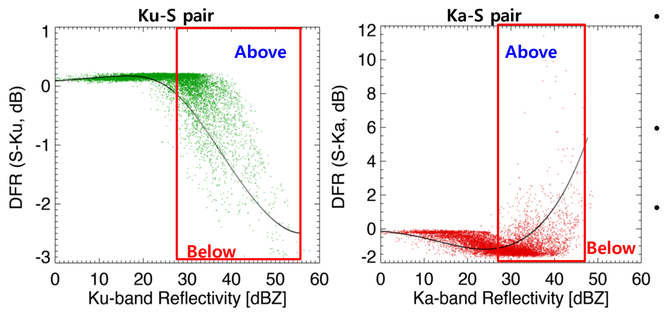
✓ BSL and SBS bias averaged between 0.5 and 1.6 degree for all rain events are 0.74 dB and -2.85 dB respectively

Z_H bias calibration using inter-comparison for GR networks (Rain events)

	BSL	BRI	GDK	GSN	GNG	JNI	KSN	KWK	PSN	SBS	SSP
Mean Bias	0.73	-4.65	-3.12	-2.28	-3.10	0.19	-1.50	-6.46	-4.17	-2.45	-2.39

3. Dual Frequency Ratio at S-, Ku-, Ka- bands

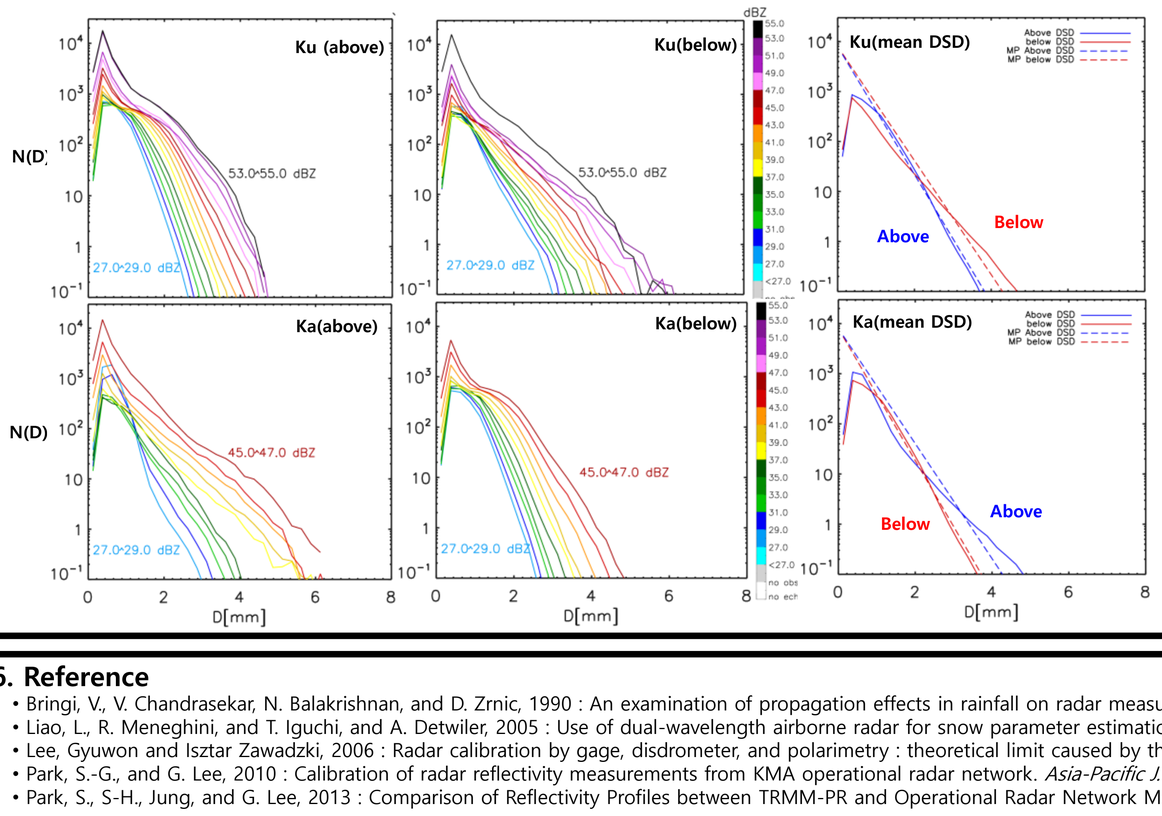
❖ Characteristics analysis of Drop Size Distribution



- Definition

$$DFR = 10\log\left(\frac{Z_{e\_longwave}}{Z_{e\_shortwave}}\right)$$

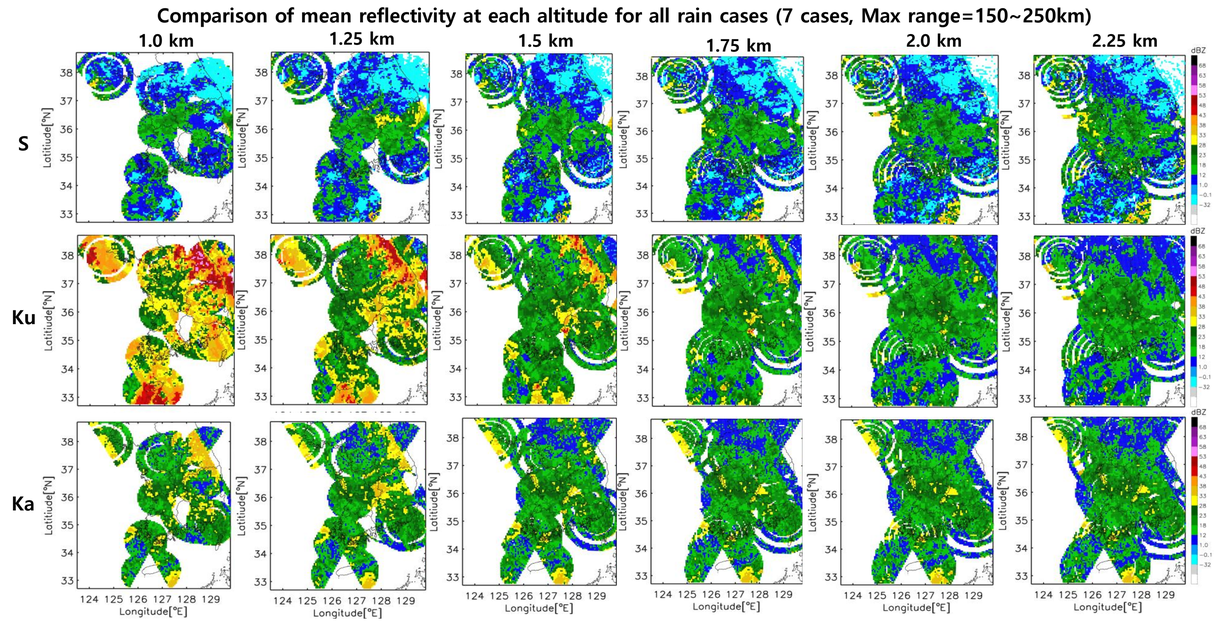
- Data : 2-Dimension Video Disdrometer (2DVD) observations at KNU campus
  (Total sample size : 9389 of 1-minute DSDs)
- Perform the analysis of DSDs for Ka-S and Ku-S DFR pairs to investigate difference between 'Above' area (higher DFR than M-P DFR) and 'Below' area (lower DFR than M-P DFR) for aspect of microphysics
  (Black line in left figures indicates M-P DFR)



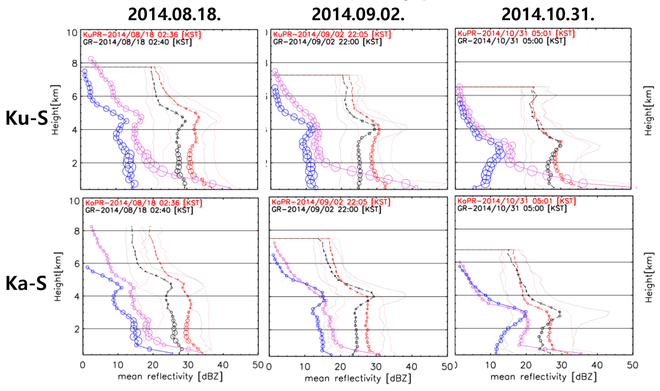
4. Result of GV between GPM DPR and GR network in rain/snow cases

(1) Rain cases

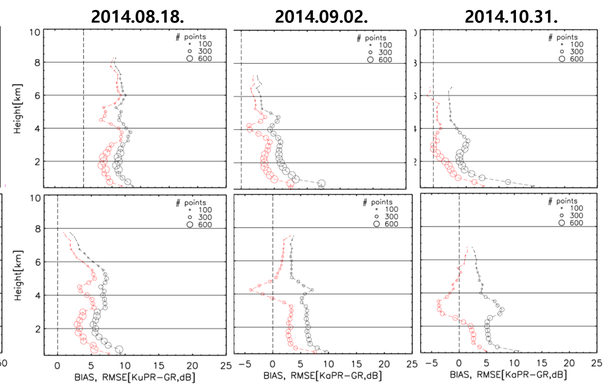
Comparison of mean reflectivity at each altitude for all rain cases (7 cases, Max range=150~250km)



Mean vertical reflectivity profiles



Result of bias(red) and RMSE(black)

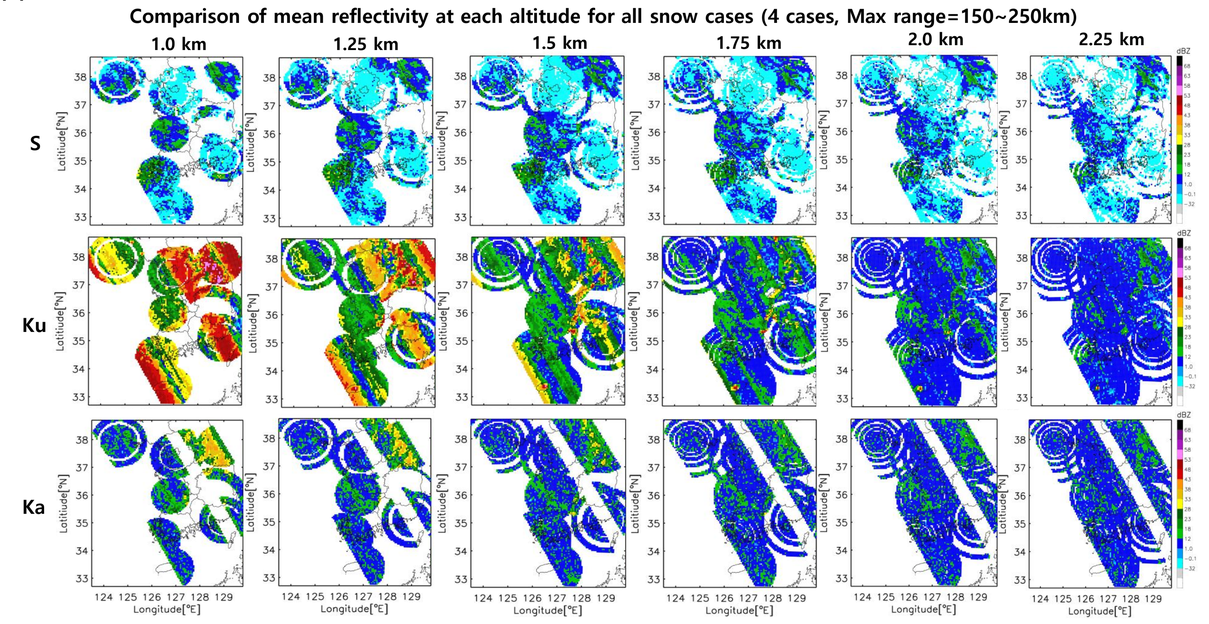


Mean reflectivity bias between GPM DPR and GR from 2.0 to 2.5km heights

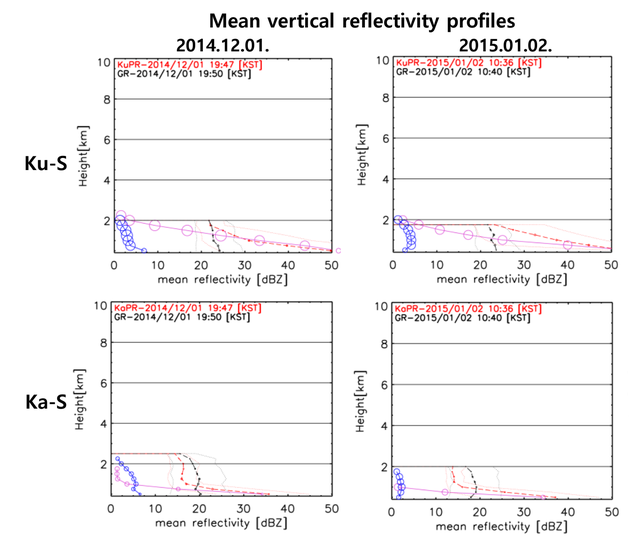
Pair \ Date	2014.08.15	2014.08.18	2014.09.02	2014.09.29	2014.10.31	2015.05.12	2015.05.30
Ku-S	2.86	3.14	3.50	0.28	1.13	1.21	3.91
Ka-S	2.89	3.68	3.02	0.89	0.73	-1.70	3.66

(2) Snow cases

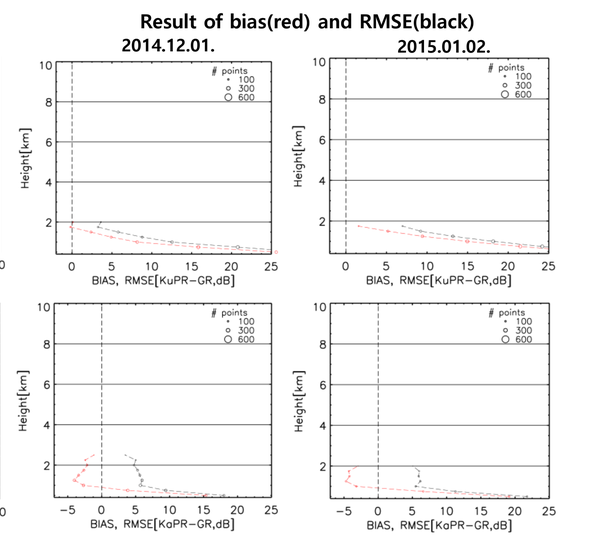
Comparison of mean reflectivity at each altitude for all snow cases (4 cases, Max range=150~250km)



Mean vertical reflectivity profiles



Result of bias(red) and RMSE(black)



Mean reflectivity bias between GPM DPR and GR from 2.0 to 2.5km heights

Pair \ Date	2014.12.01	2015.01.02	2015.02.06
Ku-S	0.12	-	0.45
Ka-S	-1.90	-2.93	-0.63

5. Summary

(1) Comparison of reflectivity between GPM DPR (Ka & Ku) and GR networks (S)

- Below melting layer: Z(Ka, Ku band) > Z(S band).
- Above melting:
  - ✓ Z(Ku band) > Z(S band).
  - ✓ Z(Ka band) vs. Z(S band) : Z(Ka band) < Z(S band) (Fall & Spring) ➔ Depends on seasons (amount of ice or low density particles)
- Snow event : Contamination by ground echoes in GPM DPR (severe in Ku band)
- BIAS of vertical reflectivity profile in lower atmosphere (2.0~2.5km)
  - ✓ Both Ku and Ka are 2~4 dB(0.5~2dB) higher than S band in summer(autumn and spring)

(2) Analysis of DFR

- Ku-S(Ka-S) : lower(higher) DFR than MP due to abundant large drops

6. Reference

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